

Highlights of The Congressional Exposition on Robotics and Intelligent Machines

“We must cooperate to compete”

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Hosted by
the Senate and House Task Forces on Manufacturing

Presented by
the Robotics and Intelligent Machines
Cooperative Council (RIMCC),
Department of Energy, and
Sandia National Laboratories





Executive Summary

More than 20 legislators, 100 Congressional staffers, and scores of Washington and national media saw an impressive display recently of U.S. intelligent machines technology and heard a broad-based call for a national initiative to build a U.S. intelligent machines industry. They came away with a clear message: there is significant interest and bipartisan support for a national initiative to enable a new intelligent machines industry that will help:

- Assure national security
- Strengthen U.S. leadership in information technology, manufacturing and services
- Create skilled, high-paying jobs for American workers
- Reduce on-the-job injuries and medical costs
- Improve productivity in manufacturing and services
- Focus intelligent systems and information technologies research at academic institutions

A national initiative responds to a widely held view in industry, Congress, the Administration, and federal agencies that the U.S. must establish and maintain a leadership role in intelligent machines.

The Message

A Once-In-A-Lifetime Opportunity for the U.S.

Intelligent machines promise to be an all new multi-billion dollar industry for the U.S. Emerging technologies are opening huge new markets to intelligent systems, rivaling these of computers and automobiles. U.S. companies lead the world in state-of-the-art sensors and intelligent controls and could capture a major share of this growing market.

If the U.S. does not protect and advance this lead, other countries will take the initiative and, as is already the case for VCRs, camcorders, and other consumer electronic products totaling \$60 billion in U.S. sales alone, the U.S. will become a buyer of technology it invented.

Advanced robotic systems are needed for defense and commercial purposes. Intelligent machines are expanding into a broad range of manufacturing and service areas that together account for 40% of U.S. GDP. U.S. leadership in intelligent systems requires leadership in information technologies, manufacturing, and services. U.S. research capabilities in intelligent systems are strong and will be further strengthened by taking hold of the present opportunity.

Protecting an Investment

The science and technology for a U.S. robotics and intelligent machines industry has been advanced by initiatives of the Department of Defense, the Department of Commerce, the Department of Energy under its nuclear weapons stockpile stewardship and maintenance program, and programs initiated by the National Aeronautics and Space Administration and the National Science Foundation. This long-term research has resulted in unparalleled technology advances for the U.S.

U.S. Leadership in Intelligent Systems - A Five-Year Commitment

U.S. companies currently lead the world in advanced sensory devices, which intelligent machines use to collect information about their environment, and in sophisticated algorithms, which intelligent systems use to respond to such information.

The national initiative calls for focusing and strengthening research in intelligent systems at universities and national laboratories, which in turn will strengthen the entire industry. Industry leaders are convinced that the U.S. intelligent machines industry has sufficient technological strength to become completely self-reliant within five years and all federal support should terminate at that time.

The Robotics and Intelligent Machines Cooperative Council (RIMCC)

RIMCC, proposed to take the lead in formation of the initiative, brings together various segments of the robotics industry: researchers, developers, materials experts, components and equipment suppliers, manufacturers, and distributors, as well as defense and commercial customers. RIMCC provides a forum for users in different sectors of the economy to present their needs and actively engages leading researchers at universities and federal laboratories. The council also opens important new market opportunities for producers and suppliers. A principal role for RIMCC is to serve as a coordinator and catalyst for research in intelligent systems and for development of new applications.

National Testbed Centers

Central to the initiative is the creation of several National Testbed Centers (NTBCs) based at leading university and national laboratory research facilities. A network of four or five strategically planned NTBCs will develop and test pre-commercial applications of intelligent systems to meet needs identified by industry and government. It is anticipated that perhaps 70% of the technology development effort at the NTBCs will be directed to manufacturing applications and the remainder toward emerging needs in construction, agriculture, mining, health and human services, transportation and logistics, and other areas.

Highlights of the Expo

The Expo showed the breadth of the applications of intelligent machines – from manufacturing to health care, from food processing to defense, from logistics to entertainment. Representatives of both industry and the research community believe that the real challenge facing the U.S. in the important area of robotics and intelligent machines is how to mobilize and take advantage of U.S. resources and seize the significant opportunity now presented by expanding national and global markets. Stated over and over was the need for a bridge between existing research and applications. Creating that bridge is the objective of the national initiative.

From the keynote speech of Dr. Patrick Eicker:



Imagine a world where smart cars avoid collisions; where surgeons guide molecularly precise instruments instead of hand-held scalpels; where satellites the size of marbles monitor rogue nations; where grasshopper-size sensors surveil a battlefield; a world that tackles problems from the galactic to the microscopic – with adaptive machine intelligence.

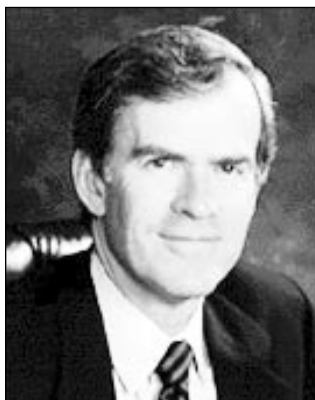
Imagine assembly workers and machines working in concert to dramatically increase national productivity – the most basic measure of national competitiveness.

Imagine whole industries arising from the creative use of sensors, software, machines and computers – intelligent machines – solving seemingly intractable problems, providing undreamed new products, exemplifying strong bonds

between workers and their companies. Imagine the industry that will grow in support – the intelligent machines industry – providing new software, sensing, and machine products. These industries promise a revolution as profound as that of the computer: Industries that create high-skilled, high-paying jobs that in turn provide additional revenue resources that can be applied to our nation's most pressing problems. Industries that greatly enhance worker and environmental safety and dramatically increase product reliability. Industries where the U.S. holds the global leadership position.

Intelligent machines technology is poised, right now, to offer national defense and commercial applications so profound that they will fundamentally transform many aspects of our everyday lives.

Senator Bingaman's (D-NM) Eight-Point Action Plan:



The essential ingredients for the next generation of robotics and intelligent machines – sensors, software, new conceptual algorithms – all are areas in which the United States now leads the world. So, while Japan has dominated the robotics industry until now, I agree with the sponsors of today's event that the United States has an excellent opportunity to lead the industry's next generation. But this leadership will not happen automatically. Our international competitors in Europe and Japan are making strong efforts to catch up to us and to nullify our potential advantages. . .

1. First, DOE, NASA, and DoD (in consultation with industry)

should develop a common technological roadmap for advanced robotics and intelligent machines, identifying areas where fundamental research is

most needed. Then, the agencies should issue a plan for addressing those needs in an integrated fashion.

2. Using existing personnel authorities that are already in the law, the three agencies should begin exchanging personnel who serve as technical managers for robotics and intelligent machines, in order to promote communication and cross-fertilization of ideas and approaches.
3. DOE and NASA should take the three prime centers for their existing robotics efforts and turn them into Testbed Centers open to other federal agencies and private sector researchers. Such centers would be analogous to DOE's current user facilities for other scientific disciplines. These centers would be located at Sandia National Laboratories, which is funded by DOE, and at Carnegie Mellon University and the Jet Propulsion Laboratory, which are both funded by NASA.

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4. An important goal of the U.S. government should be to use its standard-setting functions to encourage open system architectures for advanced robots and intelligent machines.
5. Through its Manufacturing Extension Centers, NIST should develop an infrastructure that encourages small businesses to develop and use robotics and intelligent machines.
6. Any U.S. initiative on robotics and intelligent machines needs to include studies of the ethical, legal, and social issues involved in the development and dissemination of such technologies.
7. I recommend that, to get to these issues, a Forum on Robotics and Intelligent Machines, involving manufacturing industries, labor groups, government, and other public interest groups, be established at a neutral institution such as the National Academy of Sciences.
8. The Robotic and Intelligent Machines Cooperative Council should organize a follow-on meeting involving the top leadership of DOE, NASA, DoD, and NIST. The goal of the meeting would be to convince those agencies to work out a high-level Memorandum of Understanding among themselves, so that the experts in each agency have both the mandate and the high-level direction needed to get to work on the National Robotics and Intelligent Machines Initiative as quickly as possible.

Senator Domenici's (R-NM) Support:



It is imperative that the private sector of the United States, the labor leaders of the United States, and the political leaders join together in an effort to see the true potential of robotics and intelligent machines and create a partnership vision that will once again make a breakthrough for humankind, for labor, and for all workers. If robotics reaches its full fruition, it will be a gigantic breakthrough in terms of relieving working men and women from many of their most arduous chores that are not very desirable today. It will take men and women out of positions where they have to risk their health to get things done and put in their place machinery that will respond to their commands and that will make things happen by command rather than by the backs, and the arms, and the eyes of people.

It's interesting that when we broke ground in Albuquerque, New Mexico, at the great laboratory that we have at Sandia for robotics research – which I submit that under anyone's evaluation should be considered as a national testbed – we broke ground with a robot! . . .

We can make a better living environment, a better workplace, and a better world with robotics and intelligent machines. We can enhance our productivity so that we can pay people more, so there's more to share in the marketplace of competition. Anybody involved in this revolution in technology ought to have that kind of perspective about the excitement of this work. As I see it, it is among the most exciting and forward-thinking activities that anybody could be involved in.

Let's put robotics right up there with telecommunications as something that will change the world for the better. America usually leads in these kinds of revolutions. We take great pride in that leadership. Our competitive spirit pushes us to do that. Our open marketplace pushes us to achieve. We should all believe that robotics must be developed. Certainly, it must be thought through carefully, but it must be developed. Clearly, the science, research, innovation, and the genius of man will make it work.

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Representative Marty Meehan's (D-MA) Support:



We – the Congressional Task Force on Manufacturing – will continue to work with you, hand in hand, to build this critical new industry into the powerhouse it can be for small and large manufacturers across the United States. . . Over the past year, as this national coalition on intelligent machines has formed, we have discovered and demonstrated that we can work together when the goal is clear.

In this case, the goal could not be clearer – the emerging intelligent machines industry is not about giving any particular company or small group of companies a competitive advantage. It is not about bashing other nations. It is about recognizing that by working together we will all be stronger. Building strength in intelligent machines is not about displacing today's workers, but

about creating more highly skilled, more satisfying, better-paying jobs for U.S. workers tomorrow.

We have complete bipartisan support for the intelligent machines initiative in the House. . .

With more than 100 members representing almost every state in the nation, the Congressional Task Force on Manufacturing will work with you to see this effort through to success.

Representative Robert Franks' (R-NJ) Support:



The U.S. leads the world in sophisticated sensory devices and in advanced software-based controls, and those technologies are the very core of intelligent systems, which are becoming more and more fundamental to the advanced, flexible manufacturing that our country needs to compete globally.

... Our position in this industry must not be taken for granted. What drove me to co-chair the Task Force on Manufacturing was watching U.S. manufacturers of consumer communications and electronics, precision tools, and other important products close their doors in the U.S. . . . The U.S. must not lose this opportunity to capture this emerging technology. . . . These machines are at the center of state-of-the-art manufacturing – in automobiles, electronics, aircraft, materials, and other exciting areas. We must take steps now to assure a leadership position in this vitally important new industry.

To achieve this goal, we need a broad-based, well-planned, national effort that will focus our research and development efforts on needed applications and bolster our strength in high-tech manufacturing and service areas, across the board.

DOE Assistant Secretary for Defense Programs, Vic Reis:



The role of intelligent machines in nuclear-weapon life-cycle engineering will be indispensable to the success of the program. Intelligent machines can and will provide weapon dismantlement, component storage and retrieval, and management of hazardous materials, as well as flexible manufacturing and small-lot production of vital weapons components. We see this as part of the nervous system, if you will, between what the laboratories are doing and what the production plants are doing. The way we connect is not just by sending blueprints back and forth and saying go fix this, but by really getting the entire system involved in this process.

Senator Bingaman proposed a center for robotics, a test site, a Center of Excellence. I would more than endorse the suggestion of using the Sandia facility not just for DOE, not just for stockpile stewardship, but for integrating those needs with other parts of the U. S. government that have very similar problems, that have to deal with hazardous materials, for example, or working in harsh environments. It also has to be integrated with industry, because we're not going to be building our robots ourselves; we're the users of these essential machines.

NASA's Chief Technology Officer, Sam Venneri:



From an agency mission perspective we look at intelligent machines and robotics as an integral part of our future and totally agree with the Expo context.

If I may use an aeronautic analogy, the robotic system we put on Mars this past July, the Sojourner, is akin to the Wright flier when I compare it to today's aircraft. So we're really at an embryonic stage of what we can accomplish with mobile systems in the pursuit of scientific endeavors. Look at the Sojourner as nothing more than the first step, as embryonic as the Wright flier was in opening up what is now done with space transportation. Our vision of the future isn't just bringing intelligence into robotics and sensors and computers, but opening up a whole new realm of robotics that are

thinking, learning, adaptive – that enable us to push forward out beyond earth orbit. . .

Why do we want to work with industry partnerships? We want that strong industry presence, that vision, because ultimately we want to buy a service. Twenty or ten years from now, NASA would like to buy this service from a company that doesn't exist today, a company that can provide all of our robotic service to the space station.

Joseph Engelberger, HelpMate Robotics, Inc., the “Father of Robotics”



We in the United States had all the essential robot technology. We had the first industrial robot installed in 1961. But it was very hard to convince anybody in this country to do much with it. In 1967, the Japanese government invited me to give a lecture on robotics in Japan. When I was trying to find three or four people in the U.S. willing to listen to me, they brought in 500 Japanese executives and scientists. . .

The Department of Defense in 1968 did a project on why some innovations succeed and some fail. They came up with these conclusions: first there should be a perceived need. . . The next thing you need is appropriate technology in the hands of competent practitioners. There is rich appropriate technology, and in our federal labs and in our universities we have the talent.

The last thing you need is adequate finance, and I put to you it's the adequate finance that is missing. . . I haven't heard NIH mentioned here as one of the agencies. I believe the combination of NASA technology and NIH would be a very powerful thing to lend to health care in the United States. I'm not a Japan basher, I say bully for the Japanese, shame on us, we do have all this wonderful technology in the U.S., why don't we do something with it, why don't we really create some things in volume.

Summaries of Panel Discussions:

University of Southern California professor **George Bekey** noted that universities are researching such related topics as machine intelligence (problem solving, reasoning, and learning); miniaturization (mini-robots, micro-robots, and even “nano-robots”); and group behavior (the coordination of intelligent vehicles in groups for military, security, search-and-rescue, and environmental purposes). “Further out,” he noted, “are research in emotion in intelligent robots, their interaction with humans, and teaching them to learn by imitating humans.”

Adept Technology Chairman and CEO **Brian Carlisle** concurred that intelligent machines will have a particularly strong impact on manufacturing, which makes up to 17 percent of the nation's gross national product, health care (15 percent of GNP), and defense (5 percent of GNP). He said they will also help the food industry, and even provide care for the infirm and disabled.

“We have a strong technical base for intelligent machines – the US leads the world in computing, software, and modeling,” Carlisle said. “We need to integrate those with sensors and precision mechanisms that can sense their environment, reason, and act on it.” He called for Congress to: **1)** fund basic R&D in precision mechanisms, actuators, and sensors; **2)** enable collaboration among researchers; and **3)** prove out high-risk applications in universities, “test beds,” and industry consortiums.

Dr. Gerold Yonas, Vice President, Systems, Science and Technology at Sandia National Laboratories, reviewed a number of threat scenarios that have occurred in recent years, such as hostages being held in a foreign embassy, hospitals under attack from mortars and surrounded by mines, and rogue nations launching missiles from culverts. “We need to be able to respond with precise responses based on trusted, timely, reliable information.” He envisioned squads of mobile robots and sensors sharing information to overwhelm an enemy and intelligent machines that will disarm terrorist weapons and sterilize the environment without harm to people. He noted that shrinking defense budgets made the commercial sector the new driving force and that links between the commercial sector and defense programs were critical in preserving national security.

Dr. Graham Mitchell, Assistant Secretary of Commerce, Technology Policy, analyzed international investment policies of the past 50 years and called for government-industry partnerships to alleviate the risk problem. "As we speed up the commercialization process, we benefit enormously by government providing the facility where people who are involved with the frontiers of technology can get to talk to and meet people who have the power to commercialize technology. You manage risk by not putting money into things that are highly uncertain. The risk has to be very low before you make the major commitments that allow you to commercialize. New ideas have a combination of too much uncertainty and too much cost to attract commercial capital. What we do by providing these partnerships is reduce the uncertainty to the point where ideas attract private capital."

Noting that one of the National Science Foundation's themes is "knowledge and distributed intelligence," **Dr. Bert Marsh** (acting assistant director for engineering at NSF) saw many opportunities to work closely with RIMCC "in moving forward in the area of robotic and intelligent machines . . . to see how we can make those partnerships work effectively."

Work and Technologies Institute president **Brian Turner** praised the involvement of labor in the early stages of the national initiative. "This is the first such technology initiative that has explicitly included labor in its structure." He noted that it's important to the labor movement and to all human workers that intelligent machines be used to "enhance the human presence," that the machines not only increase productivity and competitiveness but also become an advantage for workers, the machines' human partners. The work force is a stakeholder, he said; when designing smart manufacturing technologies, seek user participation in job content, working environment, living standards, and job security.

Dr. Al Narath, President, Energy and Environment Sector, Lockheed Martin Corp., reviewed the elements of successful public-private partnerships. Recognizing that the federal government has supported industrial labs and university research as well as national laboratories and other R&D institutions, he noted the wide gap between basic research and product development for commercial markets. Successful partnerships bridge this gap: "Laboratory-industry-university cooperation can serve to enhance greatly laboratory mission performance. . . Success in the execution of federal missions will increasingly require strength in interfaces with private sector science and technology developments." He concluded that "in the long run, for large initiatives to be sustainable, they have to operate in a pre-competitive domain. They are most effective when they can be built around an industrial consortium like the one proposed."

John Rueping, Assoc. Director of the Manufacturing Systems Technology Division at Kodak, presented the benefits that manufacturers can realize from flexible automation in serving diverse world-wide markets. He stressed that intelligent machines must come under a certain cost point that depended upon various costing models. He noted nine specific areas where intelligent machines already can or could impact a firm's ability to compete globally: auto-configuration and cycle optimization, error recovery and trend analysis, performance tracking, pro-active preventative maintenance, remote diagnostics, parameter memory (remembering how to set up a line for best results), and foolproofing systems.

For the full text of speeches, photos, and other materials from the Expo, please visit the Expo web site: <http://www.sandia.gov/events/WashRobo.htm>

What's Next?

The Expo was a resounding success in raising the awareness and commitment of members of Congress and their staffs and in reaching the public through national print and broadcast media. In many ways, it was the first public call for a national initiative on intelligent machines, a culmination of many years of research and effort by participants and the diverse government, industry, academic, and labor sectors they represented.

Most importantly, the Expo was only a beginning. As speakers at the Expo unanimously agreed, all participants must work cooperatively to define what needs to be done next, who is going to do it, and how it will be funded and operated. There is much to be done, both internally to organize and authorize a single voice from many different stakeholders, and externally to produce a technology and project roadmap that will benefit sponsors while achieving national goals.

Senator Bingaman's plan of action concludes: "The Robotic and Intelligent Machines Cooperative Council should organize a follow-on meeting involving the top leadership of DOE, NASA, DoD, and NIST." Planning for this meeting is underway.

Your participation and support are critical.

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